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(54) Title of the Invention: PLASMA-ETCHING SYSTEM

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SPECIFICATION

1. Title of the Invention
Plasma-Etching System

2. Claims

(1) In a plasma-etching system wherein a gas injected from said electrode surface is introduced into the space between oppositely disposed electrodes, and the target material disposed on the electrodes is etched by generating plasma by supplying high-frequency electric power between the electrodes, a plasma-etching system wherein a sintered material whose main component is a coordinate-bond carbide is disposed on one of the opposite faces of the oppositely disposed electrodes, and the target material is etched by rendering into plasma the gas that is injected through the sintered material.

(2) The plasma-etching system of Claim (1), wherein a large number of pores with a diameter of 0.2 to 0.5 mm is provided in said sintered material.

(3) The plasma-etching system of Claim (1), wherein said sintered material is a porous material with a mean pore size of 20 to 500 μm.

(4) The plasma-etching system of Claim (1), wherein the inner surface of said sintered material, on the side of the sintered material that is not facing the other, oppositely disposed electrode, is rendered into a good conductor, and the part of said good conductor is electrically connected to the electrode on the side on which said sintered material is disposed.

3. Detailed Description of the Invention

(Field of Industry)

The present invention is directed to a plasma-etching system with an improved electrode structure for the introduction of gas that is necessary for the generation of plasma.

(Prior Art and the Problems to be Solved by the Invention)

Conventionally, the material of which the gas inlet is constructed for the introduction of gas between electrodes when a gas is introduced between said electrodes from the surface of one of the oppositely disposed electrodes includes aluminum, stainless steel, graphite, glass-form carbon, the porous material of sintered quartz, and alumina sintered material. In a gas inlet using such materials as aluminum and stainless steel on which a large number of pores are created mechanically, the aluminum and nickel that compose the material are subjected to sputtering, and this creates adverse effects, such as the contamination of the target material, the problem of reaction product residues remaining on the target material, and a deterioration of the electric properties of the target material. Also, if glass-form carbon in which pores are created mechanically is used as a gas inlet, the thermal impact exerted on the sputtered film produces fine crystals, and the deposition of the fine crystals on the target material results in contamination, which is a problem. Similarly, when graphite is used as a gas inlet, a part of the graphite becomes detached and is deposited on the target material, thus contaminating it, which is a problem. Further, if porous sintered quartz is used as a gas inlet, the etching of a film of silicon dioxide can end up etching the porous sintered quartz itself, which is also a problem.

Further, in the case of the sintered quartz, the gas cavities are significantly small, measuring only 90 to 3000 angstroms, and if an attempt is made to achieve the requisite flow rate, such as approximately 900 dL/min under a high pressure of 0.5 to 1 kgf/cm^2, such as in dry-etching, the number of gas cavities increases, with the undesirable effect of a reduced strength for the porous material. The method of manufacture of the porous material involves the sintering of glass powder with a substantially uniform grain size, with the undesirable problem of difficulties in controlling the pore size and the number of gas cavities to a desirable extent.

Further, the thickness of the porous material should normally be held to less than 3μm [ILLEGIBLE], the reason being that a dielectric material, equal in amount to the thickness of the porous material, becomes inserted between the electrodes and causes a reduction in the power supplied for the generation of plasma. Therefore, if an attempt is made to create a porous quartz material with a thickness of less than 3 μm that would

cover electrodes with a normal diameter of 150 to 220 μm, there is considerable difficulty in terms of the attainable strength. Further, in the case of sintered quartz that only has small gas cavities measuring 90 to 1000 angstroms at a maximum, if etching is conducted on the SiO_2, the various reaction products that are produced in the gas plasma reactions during the etching process tend to deposit on the gas blow-out holes, which causes the blocking of the cavities and creates irregularities in the manner in which the gas blows out, with the undesirable effect of non-uniform etching.

Because it has a large dielectric loss, if sintered alumina (Al_2O_3) is disposed between electrodes and high-frequency power is applied, the efficiency of plasma generation is reduced; in addition, when the surface is exposed to the plasma and sputtered, either the alumina or separated aluminum becomes the source of contamination, which is a problem.

(Means of Solving the Problems)

In order to solve the problems identified above, the present invention provides a sintered material that is composed principally of a carbide compound on the electrodes, as a gas inlet through which gas is introduced between oppositely disposed electrodes, and a conducting substance is deposited in the interior of the said sintered material that is attached to the electrodes, thereby creating a configuration that provides an electric connection, thus reducing the generation of contamination and improving the efficiency of plasma generation.

Fig. 1 shows a lateral cross-section of a configuration that illustrates the working principles of the present invention. In the figure, Reference Number 1 denotes a gas pipe through which gas is introduced; 2, a gas inlet composed of a sintered material whose principal constituent is a carbide compound; 3, a conducting substance, such as a sputtered aluminum film, which is deposited on the inside of the gas inlet; 4 and 6, electrodes that discharge electricity for the generation of plasma; 5, target material that is subjected to ion etching and similar operations; and 7, a high-frequency power source.

In Fig. 1, the gas inlet 2 serves to direct the gas, injected through the gas pipe 1, to the space between the electrodes 4 and 6. The gas inlet is composed of a sintered material whose main constituent is a carbide compound. The gas that is injected through the gas pipe 1 is introduced from the gas inlet 2 to the space between the electrodes 4 and 6. High-frequency power is supplied by the high-frequency power source 7 to the space between the electrodes 4 and 6, which rendered the injected gas into plasma that etches the target material 5 that is disposed on the electrode 6.

(Operation of the Invention)

As shown in Fig. 1, the gas that is introduced through the gas pipe 1 is blown onto the target material 5 at a uniform flow rate through the gas inlet 2 of the present invention. Because a sintered material whose main constituent is a carbide compound is used as the gas inlet 2 through which the gas is blown onto the target material, even when the gas inlet 2 is exposed to the plasma, there is no metallic contamination from alumina and other substances. In particular, when a fluorine-based gas is used, most of the reaction products will be volatile, so that hardly any reaction products are deposited on the target material 5. Further, because the gas inlet 2 composed of a sintered material whose main constituent is a carbide compound is endowed with conductivity through the provision of the conducting material 3 in the interior of the gas inlet 2, there is little

loss of electric power, which permits the generation of stable, high-density plasma with a high degree of efficiency.

(Embodiments)

Fig. 2 shows a lateral cross-section of the configuration of Embodiment 1 of the present invention. In the figure, Reference Number 8 denotes the reaction species; and 9, an electrode ring that electrically connects the gas inlet 2 to the electrode 4. In the figure, Reference Numbers 1 to 7 correspond to those shown in Fig. 1.

In Fig. 2, the gas that flows in through the gas pipe 1 spreads in the space that is formed between the electrode 4 and the gas inlet 2. The gas that has passed through the gas inlet 2 composed of a sintered material whose main constituent is a carbide compound is blown onto the target material 5 that is disposed on the electrode 6. The supply of high-frequency power, generated by the high-frequency power source 7, to the space between the electrode 4 and 6 in this condition causes the generation of plasma between the electrodes, thus permitting the etching of the target material 5.

In this case, the use in the gas inlet 2 of a sintered material whose main constituent of a carbide compound is effective in preventing the contamination of the target material 5 and for the efficient generation of plasma. Coordinate-bond carbide compounds used as carbide compounds are chemically stable and resist the etching by the plasma. Coordinate-bond carbide compounds that can be used for this purpose include: silicon carbide (SiC) and boron carbide (BC). From a fabrication standpoint, silicon carbide that exhibits high strength and that can be obtained in a high degree of purity may be beneficial for application purposes.

In addition, the selection of a gas injection hole with a diameter of 0.2 to 0.5 mm, as done in the present invention, minimizes the generation of electric discharges in the pore section, and the gas can be squirted in a uniform manner through the provision of holes at appropriate intervals. Further, the use of a porous material with a mean pore size of 20 to 500 μm can prevent the clogging of the pores by reaction products, and permits the blowing of the gas in a uniform manner, when compared with the case where the pores are created mechanically.

Silicon carbide used as a carbide compound offers superior etching tolerance when compared with quartz or alumite (aluminum [ILLEGIBLE] oxide coating). Silicon carbide is highly tolerant of the plasma of fluorine-based gases, such as CF_4 and CHF_3, that are used in the etching of SiO_2 film, and permits uniform etching. In addition, compared with alumina, silicon carbide offers a high degree of thermal impact tolerance temperatures of 100 to 200 deg. C. As such, it is particularly beneficial for use as a gas injection plate that contains sections that are exposed to plasma and that are difficult to cool down.

The conducting film that is provided on the sintered material is made with a minimum thickness of 1 μm by sputtering and other methods, in order to obtain the requisite deposition strength. If the inter-electrode distance between the electrodes 4 and 6 is minimized for the performance of high-speed etching, the provision of such a conducting film can generate plasma with a high degree of stability when compared with the case where the conducting material 3 is not provided, and permits the further reduction of the inter-electrode distance and an increase in plasma density in order to increase the etching rate.

[Effects of the Invention]

As explained above, the present invention adopts a configuration where a sintered material, whose main constituent is a carbide compound, is attached to the electrodes as a gas inlet through which gas is introduced into the space between oppositely disposed electrodes. This eliminates any contamination of the target material. In addition, the provision of a conducting material in the inside of the gas inlet that is made of a sintered material composed of a carbide compound permits the generation of high-density plasma in a stable manner.

4. Brief Description of Drawings

Fig. 1 is a lateral cross section illustrating the working principles of the present invention. Fig. 2 is a cross-sectional view of Embodiment 1 of the present invention. In the figures, Reference Number 1 denotes a gas pipe; 2, a gas inlet; 3, a conducting substance; 4 and 6, electrodes; 5, target material; and 7, a high-frequency power source.

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Fig. 1
Gas
1. Gas pipe
4. Electrode
3. Conducting substance
2. Gas inlet
5. Target material
6. Electrode
7. High-frequency power source

Fig. 2
1. Gas
8. Reaction species
9. Electrode ring

PATENT ABSTRACTS OF JAPAN

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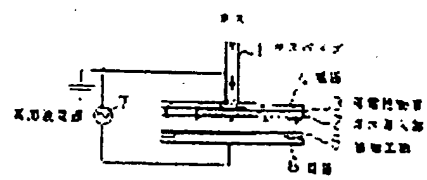
(54) PLASMA ETCHING APPARATUS

(57)Abstract:
PURPOSE: To improve plasma producing efficiency by using a sintered material which mainly contains carbon compound as a gas guide for guiding gas between electrodes to reduce a contamination.
CONSTITUTION: A gas guide 2 guides gas fed through a gas pipe 1 to between electrodes 4 and 6, and is formed of a sintered material which mainly contains carbon compound. Gas fed through the pipe 1 is guided from the guide 2 to between the electrodes 4 and 6. High frequency power from a high frequency power source 7 is supplied to between the electrodes 4 and 6 to form a plasma in the guided gas, thereby etching a workpiece 5 placed on the electrode 6. Since carbide having covalence bond and specially silicon carbide, boron carbide are chemically stable as the carbon compound to be hardly eroded by the plasma, it can be advantageously utilized.



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㊹発明の名称　プラズマエッチング装置

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㉒出　願　昭60(1985)11月8日

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明　細　書

1．発明の名称

プラズマエッチング装置

2．特許請求の範囲

(1)　相対向する電極間に当該電極面から噴射されたガスを導入し、電極間に高周波電力を供給してプラズマを発生させることにより、電極上に配置した被加工物を食刻するプラズエッチング装置において、相対向する電極のいずれかの対向面に共有結合性の炭素化合物を主成分とする焼結体を配置し、この焼結体を通して噴射されたガスをプラズマ化させて被加工物を食刻するよう構成したことを特徴とするプラズマエッチング装置。

(2)　前記焼結体に直径0．2ないし0．5mmの孔を多数もうけたことを特徴とする特許請求の範囲第(1)項記載のプラズマエッチング装置。

(3)　前記焼結体が20ないし500μmの平均気孔径をもつ多孔質体であることを特徴とする特許請求の範囲第(1)項記載のプラズマエッチング装置。

(4)　前記焼結体が相対向する他の電極に面していない内側面を良導電性にし、該良導電性にした部分を当該焼結体が配置された側の電極に電気的に接続するよう構成したことを特徴とする特許請求の範囲第(1)項記載のプラズマ処理装置。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は、プラズマを発生させるのに必要なガスを導入する電極構造を改良したプラズマエッチング装置に関するものである。

〔従来の技術と発明が解決しようとする問題点〕

従来、相対向する電極のいずれかの電極表面からガスを当該電極間に導入する場合のガス導入部の材質としては、アルミニウム、ステンレス鋼、グラファイト、ガラス状カーボン、焼結石英の多孔質体、アルミナ焼結体などが用いられてきた。

アルミニウム、ステンレス鋼などの材質を用い、これに多数の孔を機械的にあけたガス導入部を用いた場合には、当該材質を構成するアルミニウム、ニッケルなどがスパッタされ、被加工物が汚染されたり、被加工物上に反応生成物が残ったり、電気的特性が劣化してしまったりするという問題点があった。また、機械的に孔をあけたガラス状カーボンをガス導入部として用いた場合には、スパッタされた際の熱衝撃によって微結晶が生成され、この生成された微結晶が被加工物上に付着することによる汚染が生じてしまうという問題点があった。同様に、グラファイトをガス導入部として用いた場合にも、グラファイトの一部が剥離し、被加工物上に付着することによる汚染が生じてしまうという問題点があった。更に、多孔質の焼結石英をガス導入部として用いた場合には、二酸化ケイ素の膜をエッチングする際に、当該多孔質の焼結石英自体もエッチングされてしまうという問題点があった。

更に、この焼結石英の場合には、気孔径が90ないし3000Åであってかなり小さく、ドライエッチングなどのように、0.5ないし1kgf/cm²の差圧で必要な流量例えば約300cc/minを得ようとすると、気孔数が多くなって多孔質体の強度が弱くなるという問題がある。また、その製法は、ある程度粒径の揃った粉末ガラスを焼結させるものであるため、気孔径や気孔数をほしいままにコントロールできない問題点がある。

また、この多孔質体の厚みは、通常これを3mm以下程度とすることが望ましい。その理由は、厚み分だけの誘電体が電極間に挿入されて、プラズマ発生のための供給電力に減衰を生じさせてしまうためである。このため、3mm以下という厚さで、直径150ないし220mmの通常の大きさの電極を覆う石英の多孔質焼結体を作ろうとすると、強度的にかなりの無理を生ずる。更に言えば、90ないし大きくても3000Åの細かい気孔径しか持たない焼結石英では、SiO_2膜のエッチングなどを行う場合、エッチング中にガスプラズマの反応で生じた種々の反応生成物がガス吹き出し口に堆積し、孔がふさがれたり、ガス吹き出しに不均一性が生じたりして、エッチングに不均一が生じさせてしまうという問題点がある。

アルミナ(Al_2O_3)焼結体は、誘電体損失が大きいため、電極間に当該焼結体を配置して高周波電力を印加したのでは、プラズマ発生効率が低下してしまうと共に、表面がプラズマに晒されスパッタされた時、アルミナあるいは分解したアルミニウムが汚染源になってしまうという問題点があった。

〔問題点を解決するための手段〕

本発明は、前記問題点を解決するために、相対向する電極間にガスを導入するガス導入部として、炭素化合物を主成分とする焼結体を電極に配置すると共に、電極に取り付けた上記焼結体の内側に導電性の物質を付着させて、電気的な接続を行う構成を採用することにより、汚染の発生を少なくし、かつプラズマ生成効率の向上を図るようにしている。

第1図は本発明の原理的構成の側面断面図を示す。図中、1はガスを導入するためのガスパイプ、2は炭素化合物を主成分とする焼結体からなるガス導入部、3はガス導入部の内側に付着させたアルミニウムのスパッタ膜等の導電性物質、4、6は放電させてプラズマを発生させるための電極、5はイオンエッチなどを行うための被加工物、7は高周波電源を表す。

第1図において、ガス導入部2はガスパイプ1を介して流入させたガスを電極4と電極6との間に導入するためのものであって、炭素化合物を主成分とする焼結体によって構成されるものである。ガスパイプ1を介して流入したガスは、ガス導入部2から電極4と電極6との間に導入される。電極4と電極6との間に高周波電源7からの高周波電力を供給することによって、導入したガスをプラズマ化して電極6上に載置した被加工 5をエッチングしている。

〔作用〕

第1図に示すように、ガスパイプ1を通して流入したガスが、本発明に係わるガス導入部2を介して、被加工物5に対して均一な態様で吹き付けられている。また、ガスを被加工物5に吹き付けるガス導入部2として、炭素化合物を主成分とする焼結体を用いているため、ガス導入部2がたとえプラズマにさらされても、アルミニウムなどの金属汚染源がなく、特にフッ素系ガスを用いた場合、反応生成物はほとんど揮発性であり、被加工物5上に生成物が堆積されない。更に、炭素化合物を主成分とする焼結体からなるガス導入部2の内側に導電性物質3を付着させて導電性を持たせているため、電力の損失が少なく、安定かつ高密度のプラズマを効率良好に発生させることができる。

〔実施例〕

第2図は本発明の1実施例構成の側面断面図を示す。図中、8は処理槽、9はガス導入部2と電極4とを電気的に接続等するための電極リングを表す。尚、図中1ないし7は第1図に示すも に夫々対応するものである。

第2図において、ガスパイプ1を介して流入したガスは、電極4とガス導入部2との間に形成された空間に拡がる。そして、炭素化合物を主成分とする焼結体からなるガス導入部2を通過したガスが、電極6上に載置した被加工物5に吹き付けられる。この状態で電極4と電極6との間に高周波電源7によって発生された高周波電力を供給すると、プラズマが電極間に発生し、被加工物5をエッチングすることができる。

この際、ガス導入部2として炭素化合物を主成分とする焼結体を用いることが、被加工物5に対する汚染を防ぎ、効率良くプラズマを生成させるのに有効である。炭素化合物特に共有結合性の炭化物が化学的に安定でプラズマに浸食されにくい。利用できる共有結合性の炭化物としては炭化珪素（ＳｉＣ）、炭化ホウ素（B_4C）などがあるが、製造上強度的に強く、また純度の高い材料が得やすい炭化珪素を用いることが使用上有利である。

また、本発明のように、ガス噴出孔の直径を０．２ないし０．５ｍｍ程度に選ぶことで、孔部分に強放電が発生し難くなり、適当な間隔で孔を設けることで均一性の良いガスを噴出させることができる。更に、多孔質体として平均気孔径を２０ないし５００μｍ程度とすることにより、反応生成物による目詰まりを防止し、かつ機械的に孔をあけた場合に比し均一性に富んだガスを吹きつけることができる。

炭素化合物として炭化珪素を用いた場合、石英やアルマイト（アルミニウム陽極酸化被膜）に比べ、耐蝕性にすぐれ、例えばSiO_2膜を食刻するときに用いられるCF_4、CHF_3などのフッ素ガスのプラズマにも良く耐え、均一なエッチングが可能である。また、アルミナに比べ耐熱衝撃温度が１００ないし２００°Ｃ程度高く、冷却の困難なプラズマ露出面のあるガス噴出板には特に有利である。

焼結体に付加される導電性膜は、必要な付着強度を得るために、スパッタリング等の方法で例えば１μｍ以上の厚さに施されるものである。この導電性膜を付着させたときには、例えば高速エッチングを行うために電極4と電極6との間の電極間距離を小さくした場合にも、導電性物質3を付着させない場合に比し、プラズマを格段に安定に発生させることができると共に、電極間距離を一層小さくしてプラズマ密度を高くし、エッチング速度を高めることができる。

〔発明の効果〕

以上説明したように、本発明によれば、相対向する電極間にガスを導入するガス導入部として、炭素化合物を主成分とする焼結体を電極に取り付けた構成を採用しているため、被加工物に与える汚染がなく、かつ炭素化合物の焼結体によって構成されるガス導入部の内面に導電性物質を付着させているため、安定かつ高密度のプラズマを発生させることができる。

4．図面の簡単な説明

第1図は本発明の原理的構成の側面断面図、第2図は本発明の1実施例構成の側面断面図を示す。

図中、1はガスパイプ、2はガス導入部、3は導電性物質、4、6は電極、5は被加工物、7は高周波電源を表す。

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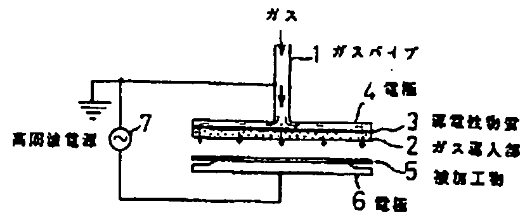
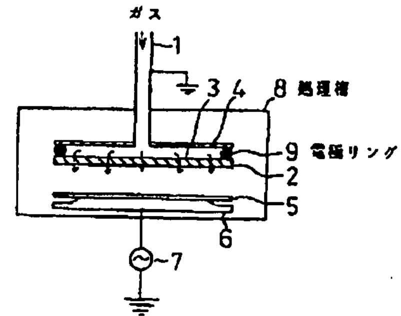


第 1 図



第 2 図